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THE DRAINAGE

OF

THE VALLEY OF THE RIVER LEE,

AND THE

UTILIZATION OF THE SEWAGE

OF THE

TOWNS WITHIN ITS WATERSHED,

AS EXPLAINED IN THE EVIDENCE

GIVEN BEFORE

THE RIVERS COMMISSION.

BY

MR. BAILEY DENTON

AND

MR. ROGERS FIELD

LONDON:

E. & F. N. SPON, 48, CHARING CROSS.

1868.

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THE object of the following evidence, when given before the Rivers Commission, was to explain a general scheme for the sewerage of the Lee valley and the purification of the river Lee and its tributaries. The main features of this scheme may be briefly stated as follows:—

It was proposed that there should be a consolidated commission formed of the various sewer authorities in the valley of the Lee outside the Metropolitan boundary, so that the sewerage of the whole valley could be dealt with on one general scheme.

The valley should then be divided into three districts.

- (1.) The Upper District, above the intake of the Metropolitan Water Companies.
- (2.) The Middle District, extending from below the intake of the Water Companies to the lowest portion of the valley capable of effective sewerage by gravitation.
- (3.) The Lower District, the remainder of the valley which is on so low a level as to require the sewage to be raised by steam power in order to obtain effective discharge.

*Upper District.*—This being above the intake of the Metropolitan Water Companies, the disposal of the sewage must be made subservient to the maintenance of the purity of the river for water supply. With this view, it was proposed that the sewage should in the first place be utilised by irrigation in such a manner as to purify it as completely as possible, and that in addition to this the water from irrigation, however pure it might appear, should not be allowed to flow into the river within a distance of eight miles above the intake of the Water Companies. There can be no question that the only *perfect* method of securing the purity of the river would be to exclude the

discharge of the sewers altogether from it above the intake; but inasmuch as this would be impracticable, the modification mentioned appears to be the only reasonable solution of the difficulty. A proper system of irrigation is the best known method of purifying sewage, and the highest chemical authorities have stated that the defœcated sewage, when mixed with a large volume of water, and having a run of seven or eight miles, is fit for domestic use.

The suggested union of the sewer authorities would render the above plan feasible, by enabling land to be obtained with facility in the valley for the application of the sewage by gravitation, and also enabling the effluent water from the irrigation meadows, within eight miles of the intake of the Water Companies, to be intercepted and discharged below the intake. Open drains or cuts would generally be all that would be required for conveying the effluent water discharged from the irrigated meadows, and probably the existing navigation might be employed for this purpose to some extent. If, in isolated cases, it were found impracticable to obtain low lands suitable for irrigation, the sewage might be raised and applied to high lands, in which case the greater depth of soil the water would have to pass through would be an additional means of purifying the sewage. Porous land, very suitable for this purpose, might be found in the watershed of the Lee. Great judgment, however, would have to be used in the choice of the land, so that the nature of the soil and its elevation might be such that there would be no danger of injury to any springs or wells interposing between the irrigated land and the river, into which the effluent water would eventually pass by underground flow.

*Middle District.*—This district being below the intake of the Water Companies, all that would be necessary would be to purify the sewage sufficiently to be innocuous when mixed with the water flowing in the river. This could easily be effected by irrigation, as the low lands by the river are admirably suited



for this purpose, and when properly laid out and provided with suitable drainage outfalls, would enable the whole of the sewage of the district to be utilized upon them by gravitation. The clarified water would be discharged directly into the river so as to feed the mills or navigation.

*Lower District.*—The distinguishing feature of this district is that it is so low as to be incapable of proper sewerage without pumping. The sewage was therefore proposed to be intercepted by culverts laid at a proper depth and to be conveyed down to Barking, there to be raised by steam-power and discharged into the Thames at high water in the same way that the London sewage is. The recent decision of the Conservators of the Thames as to the West Ham Sewage renders it doubtful whether the discharge into the Thames would be permitted, and if not, the scheme could be modified as hereafter explained. The only essential part of the scheme is, that the sewage should be intercepted by low level sewers, and raised by steam-power, so as to give effective drainage throughout the whole of the lower part of the valley, for which there does not at present exist a capability of discharge.

Some modifications will be rendered necessary in the original scheme in consequence of recent events. When the evidence was given it was assumed that the intake of the East London Water Works Company would be prolonged to Feildes Weir. The discharge of the effluent water from Hertford, Ware, &c., was therefore designed to take place below Feildes Weir. Feildes Weir still appears to be the most suitable place for the intake; but as the East London Water Works Company only propose to go at present up to Waltham, it would be necessary to carry the intercepting channels for the effluent water of the Upper District below Waltham. This will, of course, increase the size of the Upper District and diminish that of the Middle District, as compared with what was proposed in the original scheme.

As regards the Lower District, it appears probable that the discharge into the Thames, under any circumstances, will be

altogether interdicted. If this is so, the sewage will have to be raised and applied to irrigation wherever suitable land can be found. The low lands above Edmonton are so extensive and so well suited for irrigation, that it might possibly be found advisable, instead of taking the whole of the sewage of the Lower District down to Barking, to pump some of it *back* on to the marshes above. However this may be, there can be no question that the sewage of this district must be raised by artificial means.

A Plan of the Watershed of the River Lee is annexed, showing the proposed Districts, and the various Towns within them.



EVIDENCE GIVEN BY MR. BAILEY DENTON  
AND MR. ROGERS FIELD,  
BEFORE THE RIVERS COMMISSION.

*Victoria Street, 4th February, 1867.*

PRESENT :

ROBERT RAWLINSON, Esq., C.B., IN THE CHAIR.

JOHN THORNHILL HARRISON, Esq.

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Mr. J. BAILEY DENTON, examined.

CHAIRMAN : You are a civil engineer?—Yes.

You are very largely engaged in drainage and other engineering works?—Yes.

Has your practical experience been extended beyond England to Scotland or Ireland?—Yes; I recently reported on the large estate of Connemara, in Ireland, belonging to the Law Life Society, and I have had many foreign works to report upon, both in Italy and France.

How many years have you been in practice as a drainage engineer?—20 years.

To return to the river Lee, have you considered that river in all its tributaries with any particular view to the improvement of the streams, the water supply, and the land in the valleys?—Yes, I have, and the extent to which I have gone will appear from the evidence I propose now to give.

You are aware that the Lee is a navigation for a considerable portion of its length?—Yes.

That it also is a very large source of water supply to the eastern part of the metropolis?—Yes.

The water of the East London Waterworks Company and the New River Company being entirely drawn from the Lee and its tributaries?—Yes.

And that the East London Water Company and partially the

New River Company are in some degree concerned with the navigation works, that is to say, that the water which they take has been used for navigation purposes before it comes to their lowest point of abstraction?—Yes.

Mr. BEARDMORE: That would apply to the New River Company to a very small extent.

(*To the Witness*): Will you be good enough to describe the points to which you wish to draw our attention?—I should preliminarily observe that I was led into the question of the drainage of the valley of the Lee at the instigation of some of the landowners of the marshes of East and West Ham, including what is called Plaistow marsh. The plan which I now produce was prepared with a view to the formation of this area (*pointing to the plan*) into a district for its drainage which I have partially explained in the paper you have before you.

Mr. HARRISON: The object was to drain it so that it should become capable of being built upon?—Yes.

What is the level of that surface (*pointing to the plan*) as compared with Trinity high water-mark?—The section that I propose to put before you, and which you may find useful, will explain that particularly. This (*pointing to the section*) is the surface of the marsh, and this is Trinity high water-mark, that (*pointing to the same*) is Ordnance datum.

The whole of this area appears to be several feet under Trinity high-water mark?—Yes; in fact it occupies something like a mean between the two, Trinity high-water mark and Ordnance datum.

What is the difference between the two?—12 feet 6. The views entertained by the landowners at West Ham in consultation with me were, that this was a district essentially valuable for dwellings for the labouring classes, although not valuable for a high class of buildings; that it was also peculiarly available for the establishment of obnoxious trades which we wish now to expel from the metropolis.

Is it not now being built upon for that purpose?—No, I know of no buildings on the great part of the marsh, but that this is the right view is proved by the fact that at the present moment there is a bill before Parliament for the consolidation of the various gas companies of the metropolis. I believe it will be brought forward or encouraged by the Metropolitan Board of Works, whereby the manufacture of gas will take place in the parish of North Woolwich, adjoining the outlet of the northern outfall of the main drainage of the metropolis, with a frontage to Gallions Reach, and with a line of gas pipes following as nearly as possible the line of the main drain which I have proposed for

the drainage of the district, and over which I have proposed also to construct a road so as to open up this wide and large area.

That line is about midway between the northern outfall sewer, and the northern edge of the Victoria Docks?—Yes. I bring these objects before the Commission because I really think they are worthy of consideration in any scheme of drainage that may be carried out. This area, comprising 1,800 acres of land, is particularly suitable for the dwellings of the lower classes and for the location of obnoxious trades.

CHAIRMAN: You are aware, perhaps, that all this district of West Ham and part of Plaistow has been sewered?—I am quite aware of that, still the larger part of the land there remains in its primitive condition.

Mr. HARRISON: Are you aware that in the agreement or arrangement made for an outfall at West Ham at this spot (*pointing to the plan*) it was always fully intended that the sewage of West Ham should be carried eventually to a lower part down the river?—I was not aware of that.

Is the drainage of the West Ham area coincident, to any great extent, with the area you have pointed out?—It is. I believe that the lowest part of the 1,800 acres I was first proposing to deal with is somewhere here (*pointing to the plan*) in the West Ham meadows.

So that the natural fall is rather up the river Thames than down it, at that particular part?—Yes, the fall of the surface is contrary to the arterial fall.

Could you make use of the West Ham sewerage system so as to continue it eastward over the remainder of the area, carrying your outfall to the northern outfall sewer near West Ham, and pumping the whole of the sewage into the northern outfall?—I consider it unadvisable to raise the sewage of this district into the northern outfall. I have considered that the Metropolitan Board of Works would object to it, and on grounds of my own I consider it objectionable. But I wish to state that while this was under consideration, the information sought regarding West Ham led me into communication with Mr. Marshall, of Stratford, the engineer to the local board of West Ham, and he suggested to me that with other parishes of the valley there should be a combination, and that a larger work should be the result; that my original plan, in point of fact, should give way to a more extensive system of drainage. Following that suggestion I was led into communication with Mr. Marshall, no relation, but one of the same name, the engineer of Tottenham, and the design I first made was altered to suit the whole drainage of the valley. I think it right to mention that, because we desired



to suit the interests of the various parishes. The original scheme that I had formed has very much suffered thereby, for what we might have done has literally now been stopped by the difficulty of dealing with a number of parishes. The result of this joint consideration of the matter was that without altering the site of the drain I proposed for the Ham marshes, but increasing its size and altering its character, it was prolonged up the valley to the Walthamstow marsh, and from thence took the shape of a fork, passing to the east and west of the river and the navigation. This (*handing in the same*) represents the whole section of the valley; that is the Stratford sewer (*pointing to the same*) of which I believe Mr. Rawlinson was the originator. That is at the point where the sewer which I propose crosses the main sewer from Stratford (*describing*). This is the invert of my proposed sewer, which has a fall of two feet to a mile, meeting Mr. Rawlinson's sewer, which is just below Ordnance datum, and therefore more than 12 feet below Trinity datum.

Through the lower part you propose, as I understand you, to put your sewers at such a level as to intercept the sewage of West Ham?—Yes, and then to come on, first by an inclination of two feet to a mile, and then by an inclination of three feet, and rising to five, up to a point which I considered was at that time the highest point to which the low-level system of drainage, that is, the lifting system, would apply.

As far as keeping out sewage from the river Lee, your scheme, as you have explained it, would not at all improve the condition of the East London Company's water?—No, the low-level sewers would not; they have an intercepting sewer there (*pointing to the section*), and the reservoirs are fed from the water above the point to which the low-level system would apply.

The water is taken from a higher point than the highest of your low-level sewers?—Exactly so, but the district that I would include in the general scheme extends as high as Waltham Abbey, with a view to dovetail into the system the intercepting sewers from those higher grounds marked on the map, the intention being to apply that sewage for irrigation, or for any other mode of purification that might be deemed best, and to allow the overflow from those works of purification to return into the Lee; but in no case would the discharge of the sewage water into the river be above the point of abstraction by the East London Company or the New River Company. I assume that under any circumstances that would be prevented, or rather that the water companies will extend their works upwards to the point where the sewage is radically intercepted. I have prepared a statement of figures showing the cost of the proposed works, and

I am prepared to give them to the Commissioners if they think it desirable. The point of discharge would be at the same point as the North London main drainage, and I have provided in my estimate for making a reservoir at Barking creek to hold one million and a half of cubic feet, upon the assumption that 8,000 cubic feet would be brought down if the low-level system were made to this point (*pointing to the plan*) and that it would be there lifted.

CHAIRMAN: What would become ultimately of the whole of the waters brought down there by that system?—My idea was, that the Metropolitan Board of Works might possibly take the sewage into their system of reservoirs with a view to the sewage being carried on for utilization beyond, but failing that, I proposed, as I have just now said, to have an independent reservoir, and that it should conform to the same arrangement as the works of the Metropolitan Board.

With regard to the times of discharge?—Yes, and to whatever was done with the sewage.

Mr. HARRISON: If they were obliged to carry it on to the land, you would do the same, and if they discharged it into the river you would do so also?—Yes, with this advantage; that the sewage from the district I propose to form by an amalgamation of the parishes up the valley of the Lee would not be so impure as the sewage of the metropolis; that is, there would be more water in it.

Are you aware that the Thames Conservators have a bill before Parliament this year to obtain similar powers below Staines that Parliament gave them last year, to prevent any sewage being thrown into the river?—I was very glad to see the notice of that bill, but I do not know whether to read it as extending to the river Lee; if so, all the large tributaries of the Thames will be under the conservancy of the present board. I can hardly fancy that they would stop us at Barking creek when there does not appear to be any other way open of discharging it. It must be a very great improvement to discharge it there than where the Stratford sewage is at present discharged, near the mouth of the river Lee.

By this system you would do good thus far, that you would divert all the sewage from near Waltham Abbey downwards on each side of the river Lee, and discharge it at Barking creek, or pump it for irrigation lower down in Essex?—Exactly so.

You would relieve the Lee from all the pollution of the district?—I have divided this plan of mine into three parts, the first being that where the sewage must be lifted, and which I call the low-level system, and have represented by the darker colour on the map; the next is the part from the uppermost margin of the

low-level district up to Waltham Abbey—or it may be continued to Feilde's weir—of which the drainage on each side may be intercepted, and after being purified by irrigation or otherwise discharged into the river. But I have assumed that water will not be taken out of the river between those two points for domestic purposes, but above the highest point, Feilde's weir.

Is your scheme one embracing the whole of the valley, or is it merely confined to the lower part?—The scheme that I laid before, or desired to lay before, the united parishes for adoption, extended from Barking creek to Waltham, but that consisted, as I hope I have explained in the paper, of two characters of work; the low-level system, into which all the sewage must go, and the medium system, where the higher land sewage would be intercepted and applied in irrigation, if irrigation should be deemed the best.

You do not propose to deal at all with the towns of Luton, Hertford, Ware, and Hoddesdon?—I have in view the continuation of that plan, as I think I have stated in that paper, as far as a united system would facilitate the utilization of the river water for domestic purposes. The third part of my plan was this, to intercept the sewage from Feilde's weir to Hertford, and even to Hatfield, on the one side, and to Bishop Stortford on the other, and, having intercepted the sewage perfectly by a system of intercepting drains, to discharge that sewage below Feilde's weir.

On to the land?—Yes; for irrigation, or if it should be utilized on its way from Bishop Stortford to Feilde's weir, to run the effluent water into the river in its clarified condition, but below the point of abstraction for domestic use.

Will your scheme appear before Parliament of that general character that you represented just now?—Not so; one of my great motives for desiring to give evidence before this Commission was to show that if that scheme of low-level drainage in connexion with an intercepting system, and the application of the sewage to irrigation is carried out from Barking creek to Waltham it may be continued to Bishop Stortford and Hatfield by an extension of works of a similar character, whereby the water of the Lee may be utilized to a very large extent, more than it is at present. I see Mr. Beardmore present, and I am not at all sorry to promulgate my views in his presence. I consider that a system of interception might be carried out from Feilde's weir upwards by the fork, that is, to Bishop Stortford on the one side and to Hertford and beyond on the other, and that reservoirs or a reservoir might be constructed of very large dimensions below Feilde's weir. I consider that the section, which no doubt you are familiar with, the section that was



printed of the river Lee, called a profile of the Lee, shows that this can be done very clearly. I consider that a reservoir might be made of large dimensions below Feilde's weir, and the water conducted from above the weir into this reservoir. I do not look to that reservoir as the only means of storage for the Lee, because I am well aware that there are many places in the tributaries of the Lee where reservoirs may be constructed. I know intimately what was proposed by Mr. Rendel in 1849-50; I saw great objections to several of his reservoirs when I was consulted on the subject, and when I propose supplemental reservoirs higher than Feilde's weir, I am not proposing exactly those which Mr. Rendel proposed. There were some, I have reason to know, of those which he did propose, which might be still adopted, while others might take the place of those that were objectionable.

Below Feilde's weir do you get on to the London clay?—You get upon a drift of the London clay.

Is your objection to reservoirs above in consequence of their being in the chalk formation?—It was proposed to raise the water in the valleys to a height above the margin of the clay, that is, to where the chalk was exposed, so that the water would be absorbed by the chalk, and of course drop down to the subterranean level of the water in the chalk—that was my objection at that time. The cost of the system of drainage as proposed up to Waltham, including the main sewer and its two branches, a reservoir at Barking Creek, engines, and a pumping station, would be £252,000.

Did that include the main sewers?—Yes; and the reservoir, which was a costly item.

No tributaries whatever?—None whatever, but the whole drainage is so laid out as to intercept all the tributaries now existing, or which might exist, in the subordinate drainage of places on either side, such as Tottenham, Edmonton, and part of Hornsey.

You would divide the area of the Lee into three sections, utilize the upper part as the gathering ground for the rainfall, and the streams for carrying the water to a certain point; you would form intercepting sewers to Bishop Stortford, to Ware, Hertford, and other towns, and carry the sewage from them to below Feilde's weir; there you would utilize the sewage upon the land, and after irrigation pass it into the navigation below the point from which the water companies would draw their water?—Yes.

At the lower part, not being able to irrigate, you would carry it in the low-level sewer to Barking Creek, and there dispose of it in the same way as the Metropolitan Board would do?—Yes.

Do you know the valley sufficiently well to say whether there is land in the district between Tottenham and Feilde's weir that would be suitable and sufficient for irrigation?—It is impossible, I think, to find a better site for irrigation than is to be found in the valley of the Lee, with this reservation, that there will always be amongst the residents on the sides of the valley objectors to any irrigation; but viewing the suburbs, and having due regard to the character of them, I believe that no place will be found where irrigation could be carried out less objectionably. With regard to the soil, I cannot call it a stiff clay, but it is a stiff loam, with boggy peat in places, and it would require to be under-drained, both for the sake of purifying the sewage as well as benefitting the land when irrigated. There is every capability of doing it, owing to the rapid fall of the river itself when you get above Enfield marsh. The river, I think, falls something like 5 feet in a mile, or between four or five, so that the drain has only to be carried a little more than a mile to discharge the water of drainage after the sewage has passed through the soil.

CHAIRMAN: Have you any idea what area of marsh land there is to be found in the valley of the Lee and its tributaries above Stratford?—I have not calculated that.

You know that there are many thousands of acres of land now comparatively useless because it is water-logged?—Yes; it commands a good rent as it is, but it might command, if it were irrigated and drained, a very much larger rent.

Does it command as much as £1 per acre?—It now lets, I should think, at something like 50s. or £3 an acre.

Mr. HARRISON: Looking at it apart from the value it has from its nearness to London, and looking at the intrinsic value of the land, is there not a large area in the valley which is capable of very great improvement?—Very great subordinate improvement, were it provided with a sufficient outfall.

An outfall of this kind would be the most efficient way of obtaining the improvement it requires; that is, good drainage?—There is no doubt that, up to a certain point, say Enfield marsh, there is no other means of draining the land—I speak of from Barking Creek to the lower end of Enfield marsh—but with a system of low-level lifting drainage. Above that you may drain the land by ordinary land drainage, and I believe that there is every capability of applying the sewage to irrigation.

Do you not believe, looking at the Lee as a whole, that there should be a scheme proposed embracing all those points to be carried out as a whole throughout the river Lee rather than any partial work?—My notion is decidedly what you express, and I only proposed a part rather than the whole, because I considered

that if we had the large figures that would be involved in so large a work it would not be entertained at all, and, therefore, my idea was at the time to limit the work to Waltham Abbey, but that what was done in such a way should be conformable to a more extended scheme hereafter. I would add, that in the plan that I proposed, which extended up to Waltham, I added to the works which I have already stated would cost £252,000 intercepting sewers from the higher ground to lead the sewage to the lands which I propose to irrigate, and a further system of subordinate outfalls by which the irrigated lands would be drained into the river at a lower point, so as not to carry the water into the sewers, and the cost of that work would be £52,500, to which I added for the expense of lands and easements £20,000, making the total cost of the low-level system, in connexion with the interception of the high land sewage as far as Waltham, £324,500.

CHAIRMAN: Have you at all considered the rateable value of the property to be dealt with, and the rate in the pound per annum that it would take to pay the interest upon that money?—I have calculated it, and I have stated it in the paper before you.

With a view to getting rid of that burden would you prefer to pay it in 30 or 40 or 50 years?—I recommended, particularly in this report, that it should be extended to 50 years.

Would you propose to borrow a loan from the Exchequer Loan Commissioners at a low rate of interest?—That was part of the scheme; and the reason why I stated 50 years was, that the works were designed for prospective benefit rather than an immediate one, and, therefore, it was only just that the term should be a lengthened one.

Mr. HARRISON: So as to let the property as it became improved pay for the improvement which had increased its value?—Just so.

CHAIRMAN: Have you entered into any question of profit and loss, taking the value of the lands to be dealt with now, and taking the probable improved value after dealing with them, and after the expenditure of the sum of money you have named?—No. I looked upon the outfall as essential, not for the drainage of the land, but for the sewerage of the inhabited portion.

Therefore it would be a matter, the cost of which you could reasonably call upon the towns to meet, because they are now polluting the whole area by their sewage, and those works would enable them to sewer more completely, and not to commit an injury upon their neighbours?—Just so.

Mr. HARRISON: Are you going to appear before Parliament with a scheme in connection with Tottenham and other towns?



—At the present moment we are at a stand still ; plans were prepared for deposit, and they were deposited. Notices were given, and the parishes had a meeting, at which they determined to do nothing, but consider it further on the ground that if through any report emanating from this Commission, or from compulsion, they were bound to combine in the general outfall, that Parliament would suspend the standing orders, and give them the power of doing so. Therefore, the result of the meeting of the parishes was to suspend our proceedings, and the consequence has been that the original scheme for the Ham marshes has been sunk in the indifference of the parishes to their present emergency.

CHAIRMAN: We may assume that this inquiry has rather retarded than facilitated your operation so far?—It is so.

Mr. HARRISON: I suppose the result of our inquiry, if it ended in a more general scheme, would be beneficial?—It would exactly fit my notion of what ought to be done. I should mention, passing from the low-level drainage to the highest part of the district, that in my practice I have had to deal with two or three works which bear very closely upon the question before us ; for instance, I have just finished the drainage of an estate immediately above Luton ; it is but a small quantity of land, but there is a very large and constant discharge of water. The works have been in my hands something like 18 months, and I can speak with some certainty as to the large quantity of water that has been discharged from those lands. They are the property of Mr. Crawley, and the works consist of a system of under-drainage running up the valley here (*pointing to the plan*). The quantity of water delivered at that point I believe would go a great way towards supplying the whole of the town of Luton. I cannot state it positively, because I have never measured it ; but I consider there is half a million of gallons discharged daily from that drainage area alone. I believe that the people of Luton are now considering some mode of pumping the water from the chalk, and the difference between that proposal and the utilization of Mr. Crawley's water would be, as we have seen in the Thames, that the pumping would draw the surface water down into the ground to be pumped up again.

CHAIRMAN: Suppose you had to deal with the sewage of Luton, seeing that you have a choice of going up or down, the land being equally favourable both above and below, should you go up or down?—In the case of Luton I believe you have an exception to that which I consider the best plan generally, which is to go down and to discharge by gravitation. Here is an exceptional case ; the ground round Luton is of an absorbent

character, and would be very grateful for the sewage that might be spread over it ; and the height of the hills is such that when the sewage penetrated them and found its level down into the soil, the water that could pass through the soil would return to the river in a pure state. I mean chemically pure as well as clarified.

You think that there are exceptional circumstances at Luton that would induce you to irrigate the upper part of it rather than the lower?—Decidedly. Luton is surrounded by high lands of various characters, there is chalk, sand, and clay, and whatever sewage was pumped above Luton would, from the physical state of the country, pass into the soil and find its way ultimately into the river without any injury to the river itself.

If you could get an area of land sufficient to absorb all the sewage that you had, a couple of miles below, to which it could be conveyed by gravitation, might not that be cheaper than pumping it to the land above?—Yes, cheaper ; but of course it would be disadvantageous to use that water after irrigation for domestic purposes. I have taken some pains, speaking only as one of the multitude interested in the question, to discover whether water, after passing through land or over land by irrigation, enters the river in a condition fit to drink, and the result of all the attention I have bestowed upon the point has been, that it is not fit to drink. Now, I do think, that Luton, standing at the head of the Lee system, might be compelled to pump its sewage to a height that should result in the passage of that sewage through a depth of soil which should lead to its discharge in a chemically pure condition into the river.

Do you know what they do at Luton with their sewage now?—I do not.

You do not know what it cost them to deal with it?—No.

Do you know what the sewage consists of at Luton?—No, not precisely.

You are not aware that there are tons of oxalic acid which go into the river every year after being used in bleaching the straw, and many tons of acids of different kinds, and sulphur, and in fact that there are exceedingly deleterious ingredients mixed to a large extent with the sewage of Luton, and coming from the neighbourhood of Luton?—Then I consider that an additional reason why the sewerage of Luton, if it is to be utilized at all, should be utilized in such a way as that the discharge should enter the river after every possible means had been taken to purify it. I do not think that any utilization of the sewage by irrigation in the valley can of itself lead to the result we desire, which is a chemical purification of the water.

Mr. HARRISON : You think that its passage through a great

depth of chalk or soil would so chemically purify it as to make it unobjectionable?—I do think so; but I do not speak from sufficient knowledge to be able to affirm it without some slight doubt, but it is very slight.

CHAIRMAN: At present the authorities of Luton are compelled to filter the sewage of the town, and they are doing it at an annual expense of many hundreds, by a series of sediment beds. The sewage is treated by lime, and it is allowed to stand in open shallow reservoirs until deposition takes place, then the effluent water runs away into the Lee, and the mud is wheeled away?—Can anything be worse than that, except the simple discharge of the sewage at once into the river. Passing from Luton, which I referred to, because I consider it is one of the difficulties in utilizing the upper streams of the Lee, I will just mention another case on the Stort, showing the absolute necessity for strict supervision and the necessity for complete interception of sewage water. I was called upon by one of the Courts to inquire into the discharge of sewage from some dog-kennels belonging to the Reverend Mr. Arkwright. He was master of the Essex hounds, and his dogs were dressed with arsenic, as I believe is the custom for mange and other skin diseases. The dogs were occasionally fed with glandered meat by accident, at any rate glandered horses had found their way to those dog-kennels. This was near the Stort, some six miles above its junction with the Lee. It was found that the drippings of horse flesh when glandered, and the arsenic from the washing of the dogs, found their way into Harlow brook and poisoned the horses that drank out of the brook. The consequence was that Baroness North brought an action against Mr. Arkwright for the damage that her tenants had suffered, and particularly one Mr. Barnard, and the Court ruled that the practice should be discontinued, and I was called upon to see whether the discontinuance was perfect. Mr. Arkwright, finding that the Court had given this order, adopted various plans of purification and filtration, and even irrigation also; Dr. Voelcker, at my instigation, accompanied me to the spot and obtained some of the water and analysed it; although perfectly clear to the eye, and so satisfactory to all appearance, that I was very nearly drinking some of it, it was found on analysis to be as chemically impure as ever. Again, to convey to you what information I possess with regard to another tributary of the Lee, viz., the Mimram, I may state that I have just devised a scheme for draining the small town of Welwyn, and there there is no mode that I can see of dealing with the sewage, except by filtration, and discharging it into the river lower down,



the difficulty being that it is not a town sufficiently large to warrant any expensive works, and the consequence is that without some very rigid rules as to the interception of the sewage, and conveying it down to a distance where it could be used for irrigation, I at present see no means of carrying out that drainage satisfactorily.

Mr. HARRISON: Can you tell us the area of the upper portion of the River Lee which you have marked above Feilde's weir?—I cannot.

Do you know the population of that area?—I do not.

The principal towns are Luton, Hertford, Ware and Bishop Stortford; what others are there?—There are Hoddesdon and Harlow and Sawbridgeworth; but there would be no difficulty in intercepting the irrigated sewage from Bishop Stortford to Feilde's weir, nor from Fielde's weir to Hatfield, though it might be considered best to lift the sewage and apply it at a high level.

Is there any other point upon which you wish to give us information?—I should certainly like to add, by way of explanation, that in the scheme which I have endeavoured to explain to you, we have made the extent of area tributary to the river Lee after irrigation, and after the water has been clarified by it, as large as possible, and that of the low-level district as small as possible. I do not know whether you have observed it, but it is a very interesting feature in the consideration of this subject, that the New River expresses a tangible contour line to illustrate this division. You find here (*pointing to the plan*) that it is 100 feet above Ordnance datum; it rises up a little, very imperceptibly, about 1 in 10,000, and you cut off that land (*pointing to the plan*) which can be made subservient to an irrigating system. I just observe upon that to show the extent of land which might be made tributary to a system of irrigation on the Lee; of course it would extend lower than the New River as it approaches nearer to the place of distribution; but that line (*pointing to the plan*) conveys to the mind a very clear line of demarcation. Again, let me observe, as to a point upon which perhaps I was not explicit enough, that with regard to the intercepting drains which I should propose as a means of keeping the river above Feild's weir pure enough to drink, they would be open drains. I should not propose any covered drains where irrigation clarified the sewage, or else the expense would be very greatly increased.

Would you take the sewage of Hertford, Ware, Hoddesdon, and the sewage of Stortford down the valley of the Stort in an open drain?—In open cuts after irrigation,

You propose to take the sewage of Hertford, Ware, and Bishop Stortford and other towns to this mid-area, and there apply it?—Yes.

Then until it arrived at Feilde's weir, you would carry it in a close sewer?—No. I have not explained myself upon that point. I am assuming that the sewage of those various towns and villages would be applied for irrigation as it passed on its way towards Feilde's weir; if it were not purified by any system of irrigation, I am not prepared to say but that a covered conduit would be better than an open one.

You would apply the sewage of Hertford, Ware, Bishop Stortford, and all the villages and towns on the river Lee and its tributaries, to land in the most convenient places adjoining to those towns: but you would intercept the effluent water from the irrigated fields, and carry it down in open ditches to below Feilde's weir?—That is precisely what I meant.

Where it might be applied to the land, or be passed into the navigation?—That is the plan. If there were places where the sewage could not be used for irrigation, I cannot say at this moment that it would be better to convey it by a covered channel than an open one. The object would be to keep the cost of the works as low as possible.

Is there any other point that you wish to mention?—Mr. Rogers Field, who is here, has taken some pains in getting out details, but perhaps they will be surplusage at this moment; he is perfectly willing and able to answer any question as to the way in which the quantity of sewage that we propose to discharge at Barking creek has been arrived at, and the details of the cost, if you wish to examine him upon it.

The Witness withdrew.

The witness subsequently forwarded to the Commissioners the following letter:—

“ 22, Whitehall Place, London, S.W.,

“ April 16th, 1867.

“ Gentlemen,—Mr. Bazalgette has addressed a report to a committee of several parishes on the river Lee, in which he says that the sewage of the whole valley, including East and West Ham and Leytonstone, as shown by colour on a map appended to his report, ‘can be conveyed by gravitation to Barking,’ and that ‘no portion’ of the district between Hertford and Stratford is suited for irrigation by sewage

“ As this is in direct contradiction to the evidence given before your Commission on the 4th February last by Mr. Field and myself, I am desirous of an opportunity of placing before you, if it be not too late, proofs of the accuracy of the statement

then made, and of the plan and section submitted to you upon which was based a proposal to form a drainage district of the whole valley, to comprehend a low level in conjunction with a high level system of works and lifting of a portion of the sewage.

" You will observe in Mr. Bazalgette's report, that he proposes to remove the whole of the sewer of the Lee Valley to Barking Creek, there to be either utilised by the Essex Reclamation Company or discharged into the Thames, by both of which modes of disposal the water containing the sewage will be lost to the navigation and mills of the Lee.

" It is unnecessary for me to remind you that, if the benefits of irrigation shall turn out to be greater than the cost of lifting, the sewage will be readily utilized by agriculturists on the high grounds within the Lee watershed, with the twofold advantage of fertilizing the district from which it is derived, while helping to maintain the river system by the return of the effluent water after utilization. I think, too, it is equally unnecessary to point out to you that there are many reaches of low land on the sides of the Lee to which sewage may be applied with advantage by gravitation, owing to the rapid fall of the river (*see section*) which will afford a ready means of underdraining the lands to which the sewage may be applied. By removing the sewage of the Lee valley to Barking Creek on the other hand, and delivering it over to the Essex Reclamation Company for application, no part of that sewage can be applied to land without lifting; mixed as it will be with the sewage from Tottenham, which can only be discharged at a lower level than the surface of the land.

" Should your Commission be unable to hear me in further explanation of the data upon which my evidence was based owing to the time that has elapsed since I gave it, I have to beg you will allow this letter to appear in the appendix of your report as a reiteration of the following conclusions:—First, that it is utterly impossible to form a district of the whole of the Lee valley, the drainage of which shall be discharged by gravitation at all times of tide; next, that the sewage of Tottenham itself cannot be wholly discharged above high tide without recourse to mechanical agency; and last, that there are special capabilities in the upper part of the Lee basin for the utilization of the sewage of the different towns discharging into the river profitably and without objection, if the river be placed under a proper conservancy, having due regard to drainage, water supply, navigation, and mill power.

" I have, &c.,

" J. BAILEY DENTON.

" To the Rivers Commissioners."

Mr. ROGERS FIELD, C.E., examined.

Mr. HARRISON: You have been engaged with Mr. Bailey Denton in devising this scheme of interception?—I have.

Have you entered to a considerable extent into the particulars of that scheme?—I have.

I see that one of the main drains on the fork passes the towns of Tottenham, Edmonton, Enfield, and other places?—Yes, at least provision is made in the scheme for the drainage of all these towns.

Are you aware of the difficulties that those towns lie under at present, as to carrying out a complete system of sewerage?—I am.

Are you aware that Tottenham is, at present, lying under an injunction not to extend its sewerage system, which it proposed to do; and Barnet, which is an extensive parish, has been discharging its sewage into a cut that was made by the East London Water Company?—Yes.

An injunction has been obtained to prevent the authorities of Barnet from discharging any more sewage into that cut?—Yes, I am aware of that.

Would this scheme that Mr. Bailey Denton has devised and explained to the Commissioners get over the difficulty in the case of Tottenham?—Entirely.

Are the sewers sufficient to carry off the sewage from the extensive districts to the west of the Lee, in case it becomes covered with a dense population, such as appears to be growing rapidly upon it?—The sewers shown on the plan are calculated with reference to the population merely of the district that is distinguished here (*pointing to the plan*) as being the low-level; the sewage of the high-level district is intended to be utilized for irrigation, and the effluent water discharged by gravitation into the river Lee or navigation. I may explain, in reference to the principle upon which the sizes of the sewers were determined, that the population, according to the census of 1861, of the low-level district, extending from Enfield to Barking creek, may be taken at 68,000, and the present population will be about 94,000; the area is  $26\frac{1}{2}$  square miles.

If that was built upon, and so densely populated as the parts now occupied by the poorer classes of London, what would be the population upon it?—We have allowed for a different density of population in different portions of the district; for instance, the first portion, consisting principally of East and West Ham parishes, contains an area of  $10\frac{3}{4}$  square miles, with a population in 1861 of 41,000, and I have considered it might have eventually a population of 200,000. Going up-



wards, I consider the district would not be populated to anything like the same extent, and I have therefore taken about three times the population of 1861.

Why should the district not be largely populated?—Because it is getting further away from London, and judging by the rate of increase that has already taken place. In West Ham, the population has doubled itself in 10 years, in the parishes above it has only increased from 20 to 45 per cent. in 10 years.

The lower part is nearer to the river and Victoria docks?—Yes; in calculating for the other portions I have allowed about three times the population of 1861, amounting in the gross to 280,000 for the entire low-level district, the present population being 94,000 on an area containing  $26\frac{1}{2}$  square miles.

Have you any facts as to the area of land in the valley of the Lee which is applicable for irrigation, the intermediate district you calculate can be brought in and the sewage applied to the land? The population is an item of importance, and also the area of land to which the sewage could be applied.—The present population of the high-level district up to Waltham may be taken at 55,000.

What is the prospective increase that you expect?—That point has not been gone into further than to ascertain that there were capabilities for irrigation for any probable increase of population. There is a long and wide tract of level land here (*pointing to the plan*) which would be available for irrigation. It is considered that it would not be advisable to irrigate below the point B at the upper end of Tottenham marsh; but there is a considerable extent of land from B to C, near Broxbourne, which might be available, and would give an ample area for irrigation—several thousand acres.

Would that land be so close to dwellings, towns, and villages as to be a nuisance?—An ample area, I think, would be found here (*pointing to the plan*) that would be sufficiently distant from the villages, so that irrigation would be perfectly feasible; the populated parts are not nearer to the river than a mile.

Are there any other points that you wish specially to explain?—I may explain, as to the principle on which the works were designed, that it was considered advisable to make the sewers of sufficient capacity for the maximum volume that they would eventually have to take place, but that the engine and reservoir need at present only be constructed of a small size with reference to the population for the next 8 or 10 years, as they could be enlarged when required. The estimate therefore includes sewers calculated for the maximum population stated, and reservoirs and engines only for half the maximum population.

CHAIRMAN :—Do you remember what your engine power is to be?—The full engine power that would be required would be 370-horse, and we propose to provide 200-horse power for the present.

What would be the lift?—It would vary from  $12\frac{1}{2}$  to 30 feet; when the sewers were running full the lift would not exceed 24 feet, and the maximum power required is calculated for this lift.

What volume of sewage would you have to lift for 24 hours, or for an hour?—The maximum flow, including rain, that would have to be lifted ultimately would be 8,000 cubic feet a minute; half of this, or 4,000 cubic feet per minute, is what we have provided for in the first instance.

Mr. HARRISON :—This scheme is one just beyond the limits of the metropolitan district, and devised to carry out a general system of intercepting sewerage for the whole of the suburban districts of the metropolis that now drain into the Lee, and to which the system of irrigation cannot be applied?—Precisely. The low-level district has been confined strictly to those portions from which it was considered impracticable to utilize the sewage by means of irrigation. Of course, the precise limits of this district could only be defined by an accurate survey, but they have been arrived at approximately for the purposes of calculation. I think another point on which you wished for information was the rateable value of the district. This is a little over £600,000 for the entire district below Waltham, including both high and low level.

What was the rateable value of all the lower portion?—I have not got that separately.

Is this lower limit (*pointing to the plan*) the portion which you intend to rate for the execution of the works.

Mr. BAILEY DENTON : No, it extends to the whole of the tributary area from Waltham to Barking creek; for instance, we should bring in Hornsey, which lies immediately about the New River, which I have spoken of as giving a contour line, dividing that part of the district of which the sewage could be utilized from that which must go to the low level for discharge.

Witness withdrew.

Adjourned *sine die*.

## LEE VALLEY AND HAM MARSHES SEWAGE.

### MEMORANDUM AS TO DATA ON WHICH THE PROJECT IS BASED.

The valley of the Lee from the Thames to Waltham Abbey was proposed to be divided into two districts, a Low-level



District and a High-level District. The sewage from the Low-level District would be intercepted by a deep main sewer and branches which would convey the whole of the sewage of the district to Barking Creek, where it would be raised by steam power into a covered reservoir similar to the present one of the Metropolitan Board of Works, thence to be discharged into the Thames, or dealt with in any other way in which the Metropolitan sewage may eventually be treated. The sewage from the High-level District, on the other hand, would be used for irrigation, and for this purpose would be intercepted by a series of main sewers, and conveyed to various points on the meadows adjoining the Lee, the effluent water being discharged by gravitation into the river or navigation.

The following observations refer only to the Low-level District :—

#### AREA AND POPULATION OF LOW-LEVEL DISTRICT.

| Names of Parishes.                         | Area within District. | Approximate Population within District. |        | Increase per cent. | Approximate present Population. | Prospective Population provided for. |
|--------------------------------------------|-----------------------|-----------------------------------------|--------|--------------------|---------------------------------|--------------------------------------|
|                                            |                       | 1851.                                   | 1861.  |                    |                                 |                                      |
|                                            | Square Miles.         |                                         |        |                    |                                 |                                      |
| Woolwich, Barking, East and West Ham ..... | 10 $\frac{3}{4}$      | 20,367                                  | 40,596 | 99                 | 61,000                          | 200,000                              |
| Leyton and Wanstead ...                    | 3 $\frac{1}{2}$       | 4,400                                   | 5,500  | 25                 | 6,500                           | 16,000                               |
| Walthamstow and Chingford                  | 4 $\frac{1}{2}$       | 3,300                                   | 4,800  | 45                 | 6,000                           | 14,000                               |
| Tottenham .....                            | 5                     | 8,000                                   | 11,600 | 45                 | 14,500                          | 34,000                               |
| Edmonton .....                             | 2 $\frac{3}{4}$       | 4,500                                   | 5,400  | 20                 | 6,000                           | 16,000                               |
| Total .....                                | 26 $\frac{1}{2}$      | 40,567                                  | 67,896 | --                 | 94,000                          | 280,000                              |

#### SEWAGE PROVIDED FOR.

The volume of sewage is taken at five cubic feet per head per diem, and it is assumed that half this amount will flow off in six hours, giving a maximum flow of double the average daily flow.

#### RAIN PROVIDED FOR.

The amount of rain provided for varies with the nature of the districts. In the Stratford and Ham Districts, which are for the

most part below the level of high water, provision is made in the sewers for a quarter of an inch of rain *flowing off the ground* in the 24 hours, and it is assumed that the whole of the area capable of being built upon will be populated. In the districts above Stratford it is assumed that the rainfall will, to a considerable extent, be discharged into the river by the natural channels, independently of the sewers, and that storm overflows will be constructed in connection with the sewers, so that only one eighth of an inch of rainflow per diem is provided for, and a deduction is made from the whole area for the portions it is considered will not be populated.

The table on p. 27 gives the details of the prospective population, sewage, and rainflow provided for in the different districts, and the calculated diameter of circular sewers capable when running full of discharging such sewage and rainflow. The sewers provided for in the estimate are somewhat larger than the sizes given by calculation, and an allowance is made for their being, where desirable, egg-shaped instead of circular. There would, of course, be intermediate changes of dimension between the points specified in the table, so as to graduate the sewers to the work they have to perform.

#### ENGINE POWER REQUIRED.

The maximum prospective sewage and rainflow is 7,941, or say 8,000 cubic feet per minute. The lift will vary from  $12\frac{1}{2}$  to 30 feet, but the maximum lift will not occur at times of maximum flow. When the main sewer is running full, which it will be at times of maximum flow, the lift (to the top water of the reservoir) will not exceed 24 feet. The engines must therefore eventually be capable of raising 8,000 cubic feet per minute, 24 feet high, or an aggregate power will be required of (say) 370 HP. It is proposed in the first instance to provide 200 HP.

#### RESERVOIR.

Assuming that the reservoir must be capable of holding six hours maximum flow of sewage and rainfall (which exceeds the provision made in the metropolitan reservoirs), a capacity will eventually be required of 2,880,000, or say 3,000,000 cubic feet. It is proposed in the first instance to provide a reservoir of one half this capacity, or 1,500,000 cubic feet.

(Signed)      ROGERS FIELD,  
6, Cannon Row, Westminster,  
March 15th, 1867.









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